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(54) Water-microsphere suspensions for use in well cements

(57) Storable water-microsphere suspensions for use in well cements are basically comprised of water, microspheres and an effective amount of a suspending agent selected from microfine or colloidal materials and

gel forming polymers. The suspensions are mixed with a well cement composition, and the composition is then introduced into a well and allowed to set.

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Description

[0001] The present invention relates to storable water-microsphere suspensions and their use in well cements.

[0002] Hydraulic cement compositions are commonly utilized in subterranean well completion and remedial operations. For example, hydraulic cement compositions are used in primary cementing operations whereby strings of pipes such as casings and liners are cemented in well bores. In performing primary cementing, a hydraulic cement composition is pumped into the annular space between the walls of the well bore and the exterior surfaces of a pipe string disposed therein. The cement composition is permitted to set in the annular space thereby forming an annular sheath of hardened substantially impermeable cement therein. The cement sheath physically supports and positions the pipe string in the well bore and bonds the exterior surfaces of the pipe to the walls of the well bore whereby the undesirable migration of fluids between zones or formations penetrated by the well bore is prevented.

[0003] In some locations, the subterranean zones or formations into or through which wells are drilled have high permeabilities and low compressive and tensile strengths. As a result, the resistances of the zones or formations to shear are low and they have very low fracture gradients. When a well fluid such as a hydraulic cement composition is introduced into a well bore penetrating such a subterranean zone or formation, the hydrostatic pressure exerted on the walls of the well bore can exceed the fracture gradient of the zone or formation and cause fractures to be formed in the zone or formation into which the cement composition is lost. While lightweight cement compositions have been developed and used which contain microspheres for reducing the density of the cement compositions, the microspheres are usually dry blended with the cement utilized followed by mixing the dry blend with water. This procedure, however, is troublesome because it is difficult to obtain a constant cement-microsphere blend due to the differences in density between the cement and microspheres. While the microspheres can be added to the mix water, because the microspheres are lighter than the water, they float in the water.

[0004] Thus, there are needs for storable water-microsphere suspensions for use in preparing lightweight well cement compositions which can be stored at the well site or on an offshore platform for use when needed.

[0005] In one aspect, the invention provides a storable water-microsphere suspension for use in well cement compositions comprising water microspheres and a suspending agent selected from microfine or colloidal materials and gel forming polymers.

[0006] In another aspect, the invention provides a method of cementing a well bore, which method comprises the steps of

- (a) combining a water-microsphere suspension of the invention with a cement composition comprised of cement and water;
- (b) introducing said cement composition including said water-microsphere suspension into said well bore; and
- (c) allowing said cement composition to set.

[0007] The storable water-microsphere suspensions of the invention can be used for forming lightweight well cement compositions. While being stored, the suspensions normally do not separate for at least three weeks, and normally do not require stirring or agitation before use.

[0008] As mentioned above, microspheres have heretofore been blended with cement compositions to reduce the density of the cement compositions. The microspheres have generally been dry blended with the cement. However, it is often difficult to obtain a uniform microsphere-cement mixture due to the particle size and density difference of the spheres as compared to the cement particles. An alternate method of combining the microspheres with a cement composition is to add the microspheres to the mix water before combining the cement therewith. However, because the microspheres are lighter than water they float in the water making it difficult to achieve a mixture.

[0009] The present invention provides stabilized water-microsphere suspensions which are highly resistant to separation, can be stored at the job site in containers for three weeks or longer and can be added to the cement composition mixing water or to the cement composition after it has been mixed. The density of the final cement composition can be easily adjusted by adding more or less of the suspension to the cement composition. The storage of the homogenous water-microsphere suspension at the well site allows the suspension to be added to a cement composition in the required amount and any of the water-microsphere suspension not utilized can be re-stored and utilized later on another job.

[0010] The water utilized to form a storable water-microsphere suspension of this invention is preferably fresh water or salt water. The term "salt water" is used herein to mean unsaturated salt solutions and saturated salt solutions including brine and seawater. Generally, water from any source can be utilized so long as the water does not react with any of the components in the cement composition to which the water-microsphere suspension is added.

[0011] The microspheres utilized in the water-microsphere suspensions of this invention can be fly ash microspheres, glass microspheres or recycled glass microspheres. Of these, fly ash microspheres are preferred.

[0012] Particularly suitable fly ash microspheres are commercially available from Halliburton Energy Services, Inc.

of Duncan, Oklahoma, under the tradename "SPHERELITE™". Synthetic hollow glass microspheres are commercially available from the Minnesota, Mining and Manufacturing Company under the tradename "SCOTCHLITE™". The microspheres utilized are included in a suspension of this invention in an amount sufficient to produce a suspension density in the range of from about 4.6 to about 9.5 pounds per gallon, i.e., in an amount in the range of from about 25% to about 150% by weight of the water in the suspension.

[0013] The suspending agent in the water-microsphere suspension functions to prevent separation of the microspheres from the water and to maintain a homogenous suspension while being stored. In accordance with the present invention, the suspending agent is selected from microfine or colloidal materials or gel forming polymers. Examples of microfine or colloidal materials which can be used include, but are not limited to, carbon black, lignite, brown coal, humic acid, fumed silica, precipitated silica, polyvinyl alcohol latex, styrene-butadiene latex and surfactant micelle. Of these, carbon black is presently preferred. The polymers which can be used include, but are not limited to, carragenan, scleroglycan, xanthan, guar, hydroxypropylguar, hydroxyethylcellulose, carboxymethylhydroxyethylcellulose and copolymers or terpolymers of acrylamidemethyl propylene sulfonate, N,N-dimethylacrylamide and acrylic acid. Of these, carragenan is preferred.

[0014] One or more of the above described suspending agents are generally included in the water-microsphere suspension in an amount in the range of from about 0.1% to about 75% by weight of the water in the suspension. When the suspending agent is a microfine or colloidal material as described above, the microfine or colloidal material is preferably included in the water-microsphere suspension in an amount in the range of from about 25% to about 75% by weight of water therein, more preferably in an amount of about 49%. When the suspending agent is a polymer described above, the polymer is preferably included in the water-microsphere suspension in an amount in the range of from about 0.1% to about 1.5% by weight of water therein, more preferably in an amount of about 0.5%.

[0015] The methods of cementing a well bore of the present invention are basically comprised of the following steps. A water-microsphere suspension for reducing the density of a well cement composition comprised of water, microspheres and an effective amount of a suspending agent selected from the group of microfine or colloidal materials and gel forming polymers is stored. Thereafter, the water-microsphere suspension is combined with a cement composition comprised of a hydraulic cement and water. The cement composition including the water-microsphere suspension is introduced into a well bore and the cement composition is allowed to set therein.

[0016] The hydraulic cements utilized in the cement composition can be those comprised of calcium, aluminum, silicon, oxygen and/or sulfur which set and harden by reaction with water. Such hydraulic cements include Portland cements, pozzolana cements, gypsum cements, high aluminum content cements, silica cements, high alkalinity cements and slag cements. The cements can be of conventional particle sizes or they can be of ultra-fine particle sizes. Portland cements are generally preferred for use in accordance with this invention. Portland cements of the types defined and described in *API Specification For Materials And Testing For Well Cements*, API Specification 10, 5th Edition, dated July 1, 1990 of the American Petroleum Institute are particularly suitable. Preferred such API Portland cements include classes A, B, C, G and H, with API classes G and H being more preferred and class G being the most preferred. Portland cements of the types defined and described in European Norms 197-1:2000 *Cement - Part 1: Composition, specifications and conformity criteria for common cements* CEN publication date 2000-06-21 are also preferred. The cements are classified as CEM I portland cements, CEM II portland cement-fly ash mixtures, CEM III portland cement-blastfurnace slag mixtures, CEM IV portland cement-pozzolan mixtures, and CEM V composite cement blends.

[0017] The water utilized in the cement composition can be fresh water or salt water. As mentioned above, the term "salt water" is used herein to mean unsaturated salt solutions and saturated salt solutions including brines and seawater. The water is generally present in the cement composition in an amount sufficient to form a pumpable slurry, generally an amount in the range of from about 38% to about 56% by weight of cement in the composition. The water-microsphere suspension utilized in accordance with the methods of this invention is generally included in the cement composition in an amount to produce a cement composition density in the range of from about 9.8 to about 15.0 pounds per gallon, i.e., in an amount in the range of from about 20% to about 300% by weight of water in the cement composition.

[0018] A preferred storable water-microsphere suspension of this invention for use in well cement compositions comprises: water; microspheres selected from the group consisting of fly ash microspheres, glass microspheres and recycled glass microspheres present in the suspension in an amount in the range of from about 25% to about 150% by weight of water therein; and a microfine or colloidal suspending agent selected from the group consisting of carbon black, lignite, brown coal, humic acid, fumed silica, precipitated silica, polyvinyl alcohol latex, styrene-butadiene latex and surfactant micelle present in the suspension in an amount in the range of from about 25% to about 75% by weight of water therein. The most preferred microfine or colloidal suspending agent for use in the above described suspension is carbon black.

[0019] Another preferred storable water-microsphere suspension of this invention for use in well cement compositions comprises: water; microspheres selected from the group consisting of fly ash microspheres, glass microspheres and recycled glass microspheres present in the suspension in an amount in the range of from about 25% to about

150% by weight of water therein; and a polymer suspending agent selected from the group consisting of carragenan, scleroglycan, xanthan, guar, hydroxypropylguar, hydroxyethylcellulose, carboxymethylhydroxyethylcellulose and copolymers or terpolymers of acrylamidemethyl propylene sulfonate, N,N-dimethylacrylamide and acrylic acid present in the suspension in an amount in the range of from about 0.1% to about 1.5% by weight of water therein. The most preferred polymer suspending agent for use in the above described suspension is carragenan.

[0020] A preferred method of cementing a well bore of this invention comprises the steps of: (a) storing a water-microsphere suspension for reducing the density of a well cement composition comprised of water, microspheres selected from the group consisting of fly ash microspheres, glass microspheres and recycled glass microspheres present in the suspension in an amount in the range of from about 25% to about 150% by weight of water therein and a microfine or colloidal suspending agent selected from the group consisting of carbon black, lignite, brown coal, humic acid, fumed silica, precipitated silica, polyvinyl alcohol latex, styrene-butadiene latex and surfactant micelle present in the suspension in an amount in the range of from about 25% to about 75% by weight of water therein; (b) combining the water-microsphere suspension with a cement composition comprised of a hydraulic cement and water; (c) introducing the cement composition including the water-microsphere suspension into the well bore; and (d) allowing the cement composition to set.

[0021] Another preferred method of cementing a well bore of the present invention comprises the steps of: (a) storing a water-microsphere suspension for reducing the density of a well cement composition comprised of water; microspheres selected from the group consisting of fly ash microspheres, glass microspheres and recycled glass microspheres present in the suspension in an amount in the range of from about 25% to about 150% by weight of water therein and a polymer suspending agent selected from the group consisting of carragenan, scleroglycan, xanthan, guar, hydroxypropylguar, hydroxyethylcellulose, carboxymethylhydroxyethylcellulose and copolymers or terpolymers of acrylamidemethyl propylene sulfonate, N,N-dimethylacrylamide and acrylic acid present in the suspension in an amount in the range of from about 0.1% to about 1.5% by weight of water therein; (b) combining the water-microsphere suspension with a cement composition comprised of a hydraulic cement and water; (c) introducing the cement composition including the water-microsphere suspension into the well bore; and (d) allowing the cement composition to set.

[0022] In order to further illustrate the storable water-microsphere suspensions and methods of cementing in a well bore in accordance with the present invention, the following example is given.

EXAMPLE

[0023] Glass microspheres were suspended in fresh water containing 49% microfine carbon black by weight of the water to produce a suspension containing 89% glass microspheres by weight of the water. The suspension, identified as Sample No. 1, was stored and monitored over a period of 3 weeks. That is, the sample was examined for separation of the microspheres whereby they float on top of the water. If separation occurs, the microspheres form a cake on top of the suspension which prevents pouring or pumping of the suspension. Also, the development of free water and settling and whether the suspension was re-stirrable to its original consistency were monitored after 3 days and after 3 weeks. The results of these test are given in Table I below.

[0024] Fly ash microspheres were also suspended in fresh water containing 0.5% carragenan polymer by weight of the water to produce a suspension containing 50% fly ash microspheres by weight of the water. The suspension, identified as Sample No. 2, was also stored and monitored over a period of 3 weeks as described above for Sample No. 1. The results of these tests are also given in Table I below.

[0025] Portions of Sample No. 1 and Sample No. 2 suspensions were added to portions of a cement composition comprised of CEM I 52.5 Portland hydraulic cement according to EN 197, fresh water in an amount sufficient to form a slurry, and a dispersing agent comprised of the condensation product of acetone, formaldehyde and sodium sulfite present in an amount of about 1.0% by weight of the hydraulic cement. The portions of the Sample No. 1 and Sample No. 2 suspensions were present in the cement composition portions in amounts of 117% and 120%, respectively, by weight of water in the cement composition portions.

[0026] Samples of the above described cement compositions were tested for rheologies and densities at room temperature and pressure, at 4,000 psi and at 125°F. The cement compositions were also tested for free water, settling, top/bottom densities and compressive strengths at 125°F using a Universal Cement Analyzer. The results of these tests are given in Table II below.

TABLE I

Stability Of Microsphere Suspensions		
Suspension Sample Components, Properties And Stability	z Suspension Sample No.	
	1	2
Water		
Carbon Black, % by wt. of water	49	-
Carragenan, % by wt. of water	-	0.5
Glass Microspheres, % by wt. of water	89	-
Fly Ash Microspheres, % by wt. of water	-	50
Density At Atmospheric Pressure, lb/gal	7.15	7.33
Density At 4,000 psi, lb/gal	7.15	8.25
Rheology 300-200-100-6-3	131-101-66-19-15	105-90-71-35-3
Stability:		
After 3 days	no separation and free flowing	no separation and free flowing
After 3 weeks	no separation and free flowing	no separation and free flowing

TABLE II

Properties Of Cement Compositions Containing Microsphere Suspensions		
Test Cement Sample Components And Properties	Cement Compositions Containing Test Microsphere Suspensions	
Portland cement CEM 52.5		
Water, % by wt. of cement	44	44
Dispersant ¹ , % by wt. of cement	1.0	None
Sample No. 1 Suspension, % by wt. of water	117	None
Sample No. 2 Suspension, % by wt. of water	None	120
Density At Atmospheric Pressure, lb/gal	12.0	11.9
Density At 4,000 psi, lb/gal	12.1	12.5
Total Amount Of Water In Cement Composition, % by wt. of cement	63.3	61.6
Microsphere Flotation After Adding Test Suspension To Mix Water	None	None
Rheology At Atmospheric Temperature And Pressure, 300-200-100-60-30-6-3	87-69-49-40-32-24-23	30-23-14-11-8.5-7-6.5
Density, lb/gal	12.0	11.9
Rheology At 4,000 psi, 300-200-100-60-30-6-3	87-69-50-42-34-25-24	53-42-30-25-21-17-15
Density, lb/gal	12.1	12.5
Rheology At 125°F, 300-200-100-60-30-6-3	79-62-44-36-28-20-19	62-54-45-41-36-20-15
Density, lb/gal	12.0	12.5

¹Condensation product of acetone, formaldehyde and sodium sulfite.

TABLE II (continued)

Properties Of Cement Compositions Containing Microsphere Suspensions		
Test Cement Sample Components And Properties	Cement Compositions Containing Test Microsphere Suspensions	
Portland cement CEM 52.5		
Freewater, % by vol.	-	0.4
Settling, % by vol.	-	0
Density, lb/gal	-	Gelled
Compressive Strength ² , at 125°F		
50 psi at hrs:min	6:24	1:56
500 psi at hrs:min	6:53	2:48
psi at 24 hrs	3750	2275
psi at 72 hrs	4634	2600
Crush, psi	4679	4297
Cube Crush - 7 days, psi	4688	

²Universal Cement Analyzer.

[0027] From Tables I and II, it can be seen that the microsphere suspensions of the present invention can be stored for at least 3 weeks while remaining stable and can be combined with hydraulic cement compositions without adverse results.

Claims

1. A storable water-microsphere suspension for use in well cement compositions comprising water microspheres and a suspending agent selected from microfine or colloidal materials and gel forming polymers.
2. A suspension according to claim 1, wherein the water is fresh water or salt water.
3. A suspension according to claim 1 or 2, wherein the microspheres are fly ash microspheres, glass microspheres or recycled glass microspheres.
4. A suspension according to claim 1, 2 or 3, wherein said microspheres are present in said suspension in an amount of from 25% to 150% by weight of water in said suspension.
5. A suspension according to claim 1, 2, 3 or 4, wherein said suspending agent is a microfine or colloidal material selected from carbon black, lignite, brown coal, humic acid, fumed silica, precipitated silica, polyvinyl alcohol latex, styrene-butadiene latex and surfactant micelle; or the suspending agent is a polymer selected from carragenan, scleroglycan, xanthan, guar, hydroxypropylguar, hydroxyethylcellulose, carboxymethylhydroxyethylcellulose and a copolymer or terpolymer of acrylamidemethyl propylene sulfonate, N,N-dimethylacrylamide and acrylic acid.
6. A suspension according to any of claims 1 to 5, wherein said suspending agent is present in said suspension in an amount of from 0.1% to 75% by weight of said water in said suspension.
7. A suspension according to claim 1 or 2, wherein the microspheres are fly ash microspheres, glass microspheres or recycled glass microspheres and are present in said suspension in an amount of from 25% to 150% by weight of water therein; and the microfine or colloidal suspending agent is selected from carbon black, lignite, brown coal, humic acid, fumed silica, precipitated silica, polyvinyl alcohol latex, styrene-butadiene latex and surfactant micelle, present in said suspension in an amount of from 25% to 75% by weight of water therein.
8. A suspension according to claim 1 or 2, wherein the microspheres are selected from fly ash microspheres, glass microspheres and recycled glass microspheres and are present in said suspension in an amount of from 25% to 150% by weight of water therein; and the suspending agent is a gel forming polymer selected from carragenan,

scleroglycan, xanthan, guar, hydroxypropylguar, hydroxyethylcellulose, carboxymethylhydroxyethylcellulose and a copolymer or terpolymer of acrylamidemethyl propylene sulfonate, N,N-dimethylacrylamide and acrylic acid, present in said suspension in an amount of from 0.1% to 1.5% by weight of water therein.

5 9. A method of cementing a well bore, which method comprises the steps of

(a) combining a water-microsphere suspension, as claimed in any of claims 1 to 8, with a cement composition comprised of cement and water;

10 (b) introducing said cement composition including said water-microsphere suspension into said well bore; and
(c) allowing said cement composition to set.

10. A method according to claim 9, wherein the water-microsphere suspension is stored prior to use.

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EUROPEAN SEARCH REPORT

Application Number
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Place of search MUNICH		Date of completion of the search 7 March 2003	Examiner Pollio, M
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